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FINAL REPORT

HYDRAULIC AGITATION OF AN EARTHEN MANURE STORAGE

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Final Report

Hydraulic Agitation of an Earthen Manure Storage

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1. Summary

A pipe for agitating an EMS by pumping liquid into the bottom of the EMS was constructed and design trials were done with water. The pipe was then installed in an EMS and tests were done to determine if the agitation provided by this device was adequate. Influence of the manure jet from the pipe could be felt about 25 feet from the pipe. However, effective solids agitation occurred at a maximum of 10 ft. from the pipe. This, combined with a large pump and power requirements, made this system impractical for agitation of a full-scale earthen manure storage.

2. Technical Report

2.1 Introduction

During pumpout, liquid manure must be agitated to suspend the solid portion enough to be pumped out. This is most commonly done using pumps with nozzle discharges or with driven propellers. This is very large energy user, and the process is difficult to do effectively, as the solids tend to settle out of suspension quickly.

Systems are available to help agitate municipal sewage lagoons by pumping water through a grid of nozzles at the bottom of the lagoon. These systems are very elaborate and expensive. They are also often used to suck the sewage from the bottom of the lagoon after some agitation.

This project was done as a preliminary investigation to determine if a simple hydraulic agitation system could be made to work in a pig manure Earthen Manure Storage (EMS). The performance of one plastic pipe with holes drilled in it was determined in water and then in an EMS.

2.2 Objectives

Objectives of this project were to:

1) Construct a plastic pipe for hydraulic agitation and determine the optimum design parameters.
2) Determine if pumping liquid into the bottom of an EMS will provide adequate solids agitation.

2.3 General Description

The pipe used for this project was 6 in. diameter polyethylene pipe. It was rated to operate at the pressures that would normally be produced by a standard manure pump, and it was flexible enough to follow the contour of the bottom of the EMS. Holes were drilled in this pipe to act as nozzles for the manure to exit from. The hole sizes and locations depended on which tests were being done. A Houle model AP-L-R-42 manure pump was used to pump the water and manure through this pipe. A Krohne model IFM 4010 K electromagnetic flowmeter was used to measure manure flow. Sediment level was measured using an aluminum pole with a tape measure attached to it. A sheet metal paddle about 12 in. x 18 in. on the end of a metal pole was used to determine the area of influence of the liquid jets.

2.4 Scope of Test

The 6 in. diameter polyethylene pipe was obtained in 50 foot lengths. Initial tests were done by pumping water through the pipe and determining the length of the water jet. The hole size was adjusted to give a maximum jet length while considering pump performance and potential plugging.

Subsequent tests were done in an EMS near Fulda, Sask. The pipe was placed in the EMS and the depth of the sediment at the bottom of the EMS was measured. This was done by pushing a pole with a tape measure attached to it down through the manure while standing in a boat on the manure surface. The top of the sediment level and the bottom of the EMS could be felt by the operator. This process was done soon after the pipe was installed. Manure was then pumped through the pipe for about six hours. The sediment level was measured after one and five hours of pumping. During pumping, a large paddle was also used to determine the effective length of the stream coming from the nozzles.

When the EMS was being pumped out during the fall, manure was also pumped through the pipe and visual observations made. A few tank loads of manure were also sucked out of the EMS through the pipe to assess the feasibility of using the pipe as an inlet device.

2.5 Results and Discussion

2.5.1 Water Tests

For the initial water tests, 1 in. diameter holes were drilled on both sides of the pipe at 5° above horizontal. Thirteen holes were drilled at a five foot spacing and they were staggered along both sides of the pipe. Water was pumped through the pipe and the jet length, flowrate and operating pressure measured with the tractor at 1,000 PTO rpm. This test was repeated for different hole sizes up to 1.75 in. diameter. Test results are given in **Table 1**.

Table 1. Water Test Results.

Hole diameter (inches)	Flowrate (USGPM)	Pressure (psi)	Jet Length (feet)
1	1,145	24	36
1.25	1,405	16	30
1.5	1,520	13	21
1.75	1,730	6	15

As expected, the flowrate increased and the pressure decreased as the hole diameter increased. The jet length also decreased as the hole diameter increased. This appears to suggest that a small hole diameter would be most desirable, because it would result in the largest area of influence. However, it was observed that with the water source used for the tests, pieces of vegetation would occasionally plug the 1.5 in. holes but would not plug the 1.75 in. holes. This is a significant observation, as plugging with solids in an EMS is a major concern. Because of this, all further tests were done with 1.75 in. diameter holes. Another observation was that with the 1.75 in. diameter holes, the tractor appeared to be near its power limit. This is logical as centrifugal pumps, like the one used for these tests, typically consume more power at higher flowrates. Power consumption is a concern in this project as the reason for doing this research was to attempt to find a practical agitation system that uses less power than present systems.

As can be seen in **Figure 1**, even though the holes were drilled at 5° above horizontal, the jet did not get very high above the ground surface. This was affecting the jet length, as the water was contacting the ground soon after it left the pipe. This could also result in significant erosion of the EMS liner, which is very undesirable. Because of these two reasons, another pipe was constructed similar to the first one, but with the holes at 20° above horizontal. The resulting jet is shown in **Figure 2**.

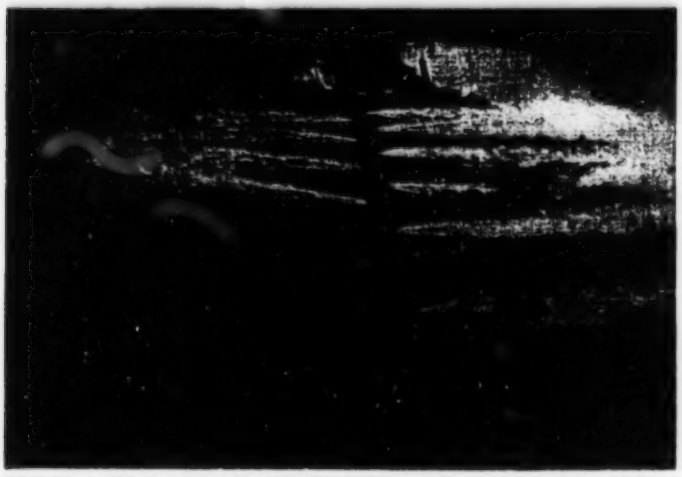

Figure 1. Water Jet with 1.75 in. Holes at 5° above Horizontal.

Figure 2. Water Jet with 1.75 in. Holes at 20° above Horizontal.

As seen in **Figure 2**, the jet was higher above the ground than the previous tests and therefore the area of influence should be increased. By changing the hole positions from 5° above horizontal to 20° above horizontal, the jet length increased from 15 ft. to 22 ft. with the pump operating at full speed. This was felt to be an acceptable starting point for the manure tests.

2.5.2 Manure Tests

Agitation Tests: For the manure tests, the 50 ft. section of pipe with the 1.75 in. holes at 20° above horizontal was attached to another section of pipe with no holes (**Figure 3**). The flowmeter and pressure gauge were installed in the pipe to measure manure flowrate and pressure. Two sections of metal conduit were attached to both ends of the pipe to indicate the pipe's location when submerged. The Houle manure pump was used to pump manure through the pipe.

Figure 3. Pipe with 1.75 in. holes at 20° above Horizontal.

All manure tests were done in an earthen manure storage (EMS) near Fulda, Saskatchewan. To install the pipe in the EMS, the free end was placed on a pair of rowboats and fed out across the liquid surface (**Figure 4**). When in place, the pipe was lowered into the manure and allowed to sink to the bottom. The location of the pipe and its degree of submergence could be determined by the sections of conduit attached to the pipe ends. An aluminum rod with a tape measure attached to it was used to determine that there was about 4-5 ft. of solids in the EMS where the pipe was installed.

Figure 4. Installing Pipe in the EMS.

Every time the pump was started, the air in the system had to be forced through the pipe. This caused the pipe to rise out of the water until the air was all forced out (**Figure 5**). This was not a major problem, but if this system would be installed permanently in an EMS, this would have to be addressed.

Figure 5. Air Bubble lifting Pipe.

When the air was forced out of the system and manure pumped though it for about two hours, a 12 in. x 18 in. paddle on the end of a long handle was used to determine the area of influence of the pipe. With this paddle, fluid flow could be felt up to 25 ft. from the pipe. However, it was thought that the fluid velocity was not high enough to keep the solids suspended. During these tests, with about 8 ft. of manure above the pipe, there was no visible agitation at the liquid surface. Operating pressure was 8 psi and the manure flowrate was 1,700 USGPM.

The results of the sediment level tests are given in **Figure 6**.

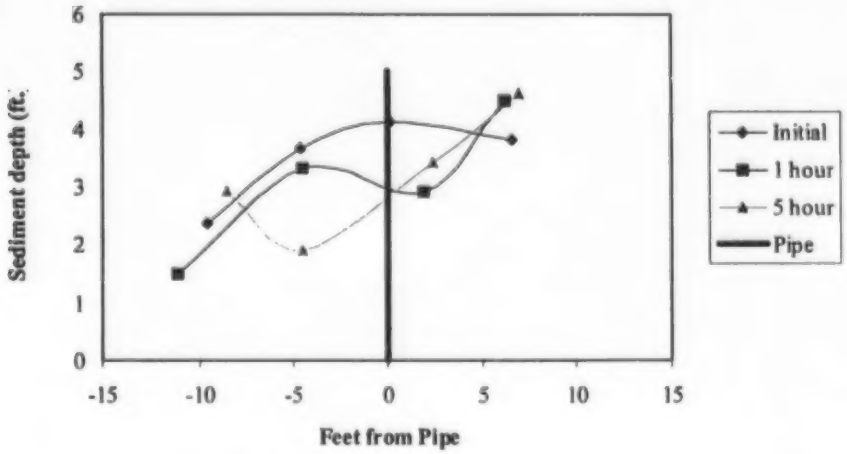

Figure 6. Sediment Level Test Results.

After one hour of operation, the sediment level to the left of the pipe was reduced slightly, and to the right of the pipe, the sediment had been moved over. It could not be determined where the hole in the pipe was relative to the probing location. After five hours of operation, the sediment level had been reduced somewhat next to the pipe compared to the initial level, but between 7 and 10 ft. from the pipe the sediment level was higher than the initial level. This indicates that the sediment had been moved 7 to 10 ft. from the pipe, but was not being held in suspension any further than this.

When the EMS was nearly empty, the pipe was used again to visually observe its operation. At this time there was about 3 ft. of manure remaining in the EMS and there was a pile of solids about 2 ft. from the pipe (**Figure 7**). Manure was pumped through the pipe and a swirling action was noted on the liquid surface up to 10 ft. from the pipe. However, the island next to the pipe was not being eroded by the fluid jets.

Figure 7. Pipe Operation with 3 ft. of Manure Depth.

Tank Filling Tests: To determine if this pipe could be used to draw manure out of the EMS, a vacuum tank was filled using the pipe as an inlet. This worked well, as three tankfulls were drawn through the pipe with no plugging occurring. This could have been due to the pipe previously having been used as an agitator and therefore there would be few solids next to the holes. If this were the case, and this system was used to draw manure out of the EMS, it may be periodically necessary to pump some manure back into the EMS to unplug the holes. The maximum flowrate attained during these tests with the tank used was 630 USGPM.

Conclusions: The previous observations suggest that this system would not be very effective in agitating an EMS, at least not as attempted. It was hoped that the area of influence would be such that if an entire EMS were to be agitated with this system, only three or four pipes would be needed. With an area of influence of not more than 10 ft. on either side of the pipe, this would require more than the three or four pipes per EMS that was originally hoped for. This area of influence could be enlarged by increasing the velocity out of the holes. This could be done by decreasing the hole size, but this would increase the risk of plugging. The flowrate could also be increased, but this would require a larger pump and a larger tractor. This is not desirable, as the reason for doing this project was to try to reduce the power and pump requirements for EMS agitation.

The pump and tractor used for this project are typical of what is used for agitating manure, so a requirement for a larger power source or pump would not be seen as an improvement. To be successful, this system would have to be lower cost, work as well or better, and use less power than a standard manure agitator pump.

Even though the pump was developing 8 psi of pressure at the flowmeter, not all of this pressure was available to be converted into fluid velocity and therefore manure agitation. Because the pipe was 8 ft. under the liquid surface, 3.5 psi are needed to overcome the static pressure from the fluid above the pipe. There also is pressure lost because the hole drilled in the pipe is a sharp edge, which causes more turbulence than a rounded edge. This could be 1 psi or more, which would leave an effective pressure of 3.5 psi available for actual manure agitation. The losses due to the sharp edge could be mostly overcome by using a more rounded edge nozzle, but this would add cost to the system and the practicality would have to be assessed. Overcoming the 3.5 psi due to fluid depth could only be done with more pump pressure, which could only be obtained with smaller holes that may plug.

It is also possible that raising the angle of the holes from 5° to 20° above horizontal may have aimed the jets above the solids and therefore reduced the effectiveness of the agitation. However, unless the pipe was very well anchored in a new EMS, reducing the angle below 20° would be risky, as this would require precise placement of the pipe to ensure that the jets o not erode the EMS liner. This cannot be guaranteed when placing the pipe in an existing EMS. If the solids are deep enough, another option would be to leave the holes at 20°, accept that the solids below the jets that will not be disturbed and subtract this unavailable volume from the available EMS volume.

It should be noted that these tests were done using only 25 ft. of pipe. If this system were used to agitate a complete EMS, much more pipe would be needed, which would again require a much larger pump and power unit. This would not be practical.

In summary, the simple agitation pipe attempted would not work. A more complex design using exit nozzles, smaller outlets, a method to prevent plugging, such as alternate agitate and then pump out cycling, as well as a switchable manifold system may all help to make such a system work but this project did not confirm that. This project did illustrate that a simple hydraulic agitation system is not possible.

Regarding the tank filling tests, it appears that this system could be used to remove manure from the bottom of the EMS. Two potential problems exist. The small holes in the pipe may result in a large pressure drop and result in a lower flowrate than with an open pipe. Also, if this system was used to empty an entire EMS, it would probably be necessary to have a system to choose which portion of the pipe the manure was being drawn from.

4. Equipment

No equipment has been purchased for this project.

5. Project Developed Materials

To date, no materials have been developed for this project. The information from this project is intended to be included in an upcoming PAMI Research Update.

6. Project Photos

The photos for this project are included in the body of this report.

7. Acknowledgement

To date, the results from this project have not been publicized. In all future press releases, reports or other information dissemination, support from the Department will be acknowledged.